File

24 January 1964
LEG:vg-28

Chief, Office of Naval Research
Department of the Navy
Washington 25, D. C.

Declass Review by NGA.

Attention: Code 414, [redacted]

Subject: Contract [redacted] Application of Perceptron Concepts to Photo-Interpretation

Enclosure: Nine Copies of Letter Report No. 23

Dear Sir:

We are enclosing nine copies of Letter Report No. 23 covering our technical progress under Contract [redacted] during December 1963.

Of the contract estimated cost as amended by Modification #6 amounting to [redacted] we have expended [redacted] as of 31 December 1963, leaving a balance of [redacted] In terms of cumulative labor and indirect costs under the contract, the following is a summary as of 29 December 1963:

[redacted]

STAT [redacted]

Attachment to Letter
LEG:vg-28 dated 1/24/64

1. Commanding Officer
U. S. Naval Photo-Interpretation Center
Suitland, Maryland

STAT [redacted]

STAT 2. [redacted]
Photographic Management Division
Bureau of Naval Weapons
Naval Weapons Plant, Bldg. 200
Dept. of the Navy
Washington 25, D. C.

3. Commanding Officer
U. S. Naval Photo-Interpretation Center
Suitland, Maryland

STAT [redacted]

STAT 4. [redacted]
CNO (OP-07T12)
Dept. of the Navy
Washington 25, D. C.

5. Office of Naval Research
Information System Branch
Washington 25, D. C.

STAT [redacted]

6. Office of Naval Research
Systems Analysis Branch
Washington 25, D. C.

[redacted] STAT

Letter Report No. 23

Investigation of Perceptron Applicability to

Photo Interpretation

[redacted] STAT

Monthly Letter Report

for the month of December 1963

STAT

[redacted]

[redacted]

Letter Report No. 23

Investigation of Perceptron Applicability to
Photo Interpretation

Monthly Letter Report
for the month of December 1963

1.0 INTRODUCTION

Project PICS is an investigation of the applicability of perceptrons to automation of certain parts of the photo interpretation task. Particular emphasis is placed on area and object recognition based upon properties derived from two-dimensional power spectra. Accordingly, effort is centered in the following major areas:

1) Theoretical and experimental evaluation of the properties which can be derived by optical spatial filtering.
2) Design and implementation of a recognition system based upon such properties.
3) Design of optical-electronic spatial filtering equipment.
4) Research based upon ideas whose immediate applicability cannot be stated, but of potential long-term benefit.

2.0 ACTIVITY AND ACCOMPLISHMENTS DURING DECEMBER 1963

2.1 Project Review

Two meetings with sponsoring agency personnel occurred:

Washington, D.C., 12/6/63 [redacted] STAT

STAT Attendees: [redacted]

Their chief purpose was to review progress on the design of optical-electronic spatial filtering equipment, and to discuss the application of coherent optics to photo-interpretation.

2.2 Property Evaluation

No work on spectral property evaluation was done in December. STAT

2.3 Design of Optical-Electronic Spatial Filtering Apparatus

The optical portions of the filtering apparatus were set up in the [redacted] clean room during December. The first set-up early in December used an Osram 100 watt mercury (5460 Å) source, a 1/8 millimeter pinhole, collimator and object lenses, a liquid gate holding the test transparencies, and a Kintel television system with a standard 7735-A vidicon.

The first set-up provided strong display signals from standard test patterns and half-tones, but the luminance levels at high spatial frequencies were marginal for photographs. The total power in the collimated light beam directed through the objective transparency was measured to be about 0.25 microwatt.

Even with the marginal light levels, the brightness of the central (low-frequency) spot on the vidicon was sufficient to damage the tube. This is indicative of the dynamic range problems imposed on pickup devices in the frequency plane.

A second set-up in mid-December (nearly identical to the first) was STAT demonstrated during the [redacted] project review meeting. To reduce the dynamic range at the vidicon, and thus allow more vidicon sensitivityto be used, a small central disk occluder was used at the frequency plane. This was then imaged on the vidicon sensitive surface. The conclusion of usually-inadequate light level was reached as before, although some high frequency structure was visible on the TV monitor for strong object-transparency features.

In a working system, a variable density, circularly symmetric filter designed to strongly attenuate, but not completely block, the low frequency signal would be used. Thus the dynamic range would be reduced, but the ability to obtain data everywhere in the spectrum would be maintained. Such a filter is called a "pre-whitening" filter.

Preliminary design of electronic circuity which will produce the desired types of integration areas in the frequency plane was completed during December. Special purpose logic equipment of conventional design, driven from comparators which use functions of the raster-scan sweep voltages as inputs, is used to derive a video gating signal during the time that the vidicon read-out beam is interrogating the desired raster areas. A wide variety of interesting area shapes and sizes are readily accomodated by this design.

The only unusual electronic design problem is that presented by the necessity to remove the attenuation inserted by the pre-whitening filter. A wide-bandwidth variable-gain amplifier is required.

2.4 Recognition Studies

The ordinary viewpoint of the weight derivation (training) process of a perceptron is that of moving a plane in the binary n-space defined by the A-unit activities, such that the members of two classes are separated. Several new insights into the problem are available if one considers the dual problem. That is, we define the space of interest by the A-unit weights. In this space, each stimulus is a hyper-plane and a set of weights is a point. A solution is represented by any point within a convex region determined by the stimulus planes and their required classification.

Because of the convexity of the solution region (if it exists) many properties of the set of solution are immediately apparent. For example, given W_1 and W_2 any two weight vectors which are solutions, then $aW_1 + (1-a)W_2$ is also a solution for all $1 \leq a \leq 0$.

Using these new (to perceptron theory) concepts a new method of training was postulated. It depended upon successive relaxation of the boundaries of the solution region, followed by a step toward the interior of the region. Several trial examples showed that no simple method known to the experimenters will yield a step toward the interior of the region when the current trial point is at a vertex of order higher than two. Since this is an extremely likely event at an early stage in the solution, work on this particular training method has been suspended.

It is expected that the really very fruitful dual viewpoint may yield additional new techniques for trial. A particular problem that may well be attacked from this outlook is that of effective discovery of training problems which have no perfect solution. We also hope to shed some light on the multiple solution problem.

3.0 PLANS FOR JANUARY 1964

3.1 Design of Optical-Electronic Spatial Filtering Apparatus

During January 1964 the following are expected to be accomplished:

1) Operation of a clean room mock-up using a gas laser in the visible red (6328Å) as a light source. This experiment would

investigate the increase in brightness and coherence apparently available from a laser source, and indicate problem areas (reflections, mechanical alignment, lens quality) emphasized by this type of source.

2) Preparation of a memorandum describing the filtering apparatus experiments, results to date, and conclusions.

3.2 Recognition Studies

Continued investigation of the training problem from the dual viewpoint are planned.

4.0 REPORTS

No reports other than the regular monthly letter report were due or issued during December.